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Journal of the Society of Arts.

FRIDAY, MAY 1, 1863.

**ADDRESSES OF CONGRATULATION
TO HER MAJESTY AND HIS ROYAL
HIGHNESS THE PRINCE OF WALES.**

The following address has been forwarded to the Secretary of State for the Home Department for presentation to Her Majesty :—

TO HER MOST GRACIOUS MAJESTY THE QUEEN.

We, the President, Vice-Presidents, Council, and Members of the Society for the Encouragement of Arts, Manufactures, and Commerce, in General Meeting assembled, desire humbly to approach your Majesty with our loyal and hearty congratulations on the auspicious marriage of his Royal Highness the Prince of Wales with her Royal Highness the Princess Alexandra of Denmark.

Impressed with the recollection of the important benefits the Society has derived for so many years from the guidance and wise counsel of his Royal Highness the Prince Consort, we feel it our grateful duty to express the heartfelt interest we take, in conjunction with every subject of your Majesty, in the marriage of his Royal Highness the Prince of Wales, and to express our most ardent hope that this event is but the commencement of a noble career which will become the source of true consolation to your Majesty, and of happiness to the Royal family, as well as prove a blessing on this nation.

And we humbly pray that your Majesty may long live to reign over a prosperous and loyal people.

The following address was presented to His Royal Highness the Prince of Wales at Marlborough House, on Wednesday, the 29th inst., by a deputation, consisting of Sir Thomas Phillips, Vice-President and Chairman of the Council, Mr. W. H. Bodkin, Vice-President, Mr. W. H. Marsh, M.P., Vice-President, and the Hon. and Rev. Samuel Best, Member of the Council :—

TO HIS ROYAL HIGHNESS THE PRINCE OF WALES.

We, the President, Vice-Presidents, Council, and Members of the Society for the Encouragement of Arts, Manufactures, and Commerce, in General Meeting assembled, approach your Royal Highness with every demonstration of affection and respect, to express our sincere congratulations on your Royal Highness's marriage with her Royal Highness the Princess Alexandra of Denmark. We trust that this auspicious event, whilst proving a source of true and lasting happiness to your Royal Highness and your illustrious bride, will, by the influence of her virtues and graces, perpetuate that social excellence in the minds and habits of the people of which your revered mother, the Queen, supported by his Royal Highness the Prince Consort, has set so bright an example.

**THE SOCIETY'S MEMORIAL OF THE
PRINCE CONSORT.**

The following circular, with an abstract of the proceedings of the General Meeting held on the 7th Feb., has been issued to the members :—

Society of Arts, Adelphi, London, W.C., Feb., 1863.

SIR,—I am directed to bring to your notice the subjoined proceedings of a Special General Meeting of this Society, held on Saturday, the 7th instant.

Should you desire to have your name placed on the list of subscribers, I shall feel obliged by your filling in the accompanying paper, and returning it to me, with your subscription, which may be in the form of a post-office order or cheque, made payable to the Financial Officer, Mr. Samuel Thomas Davenport, and crossed Coutts and Co.

I am, Sir, your obedient servant,

P. LE NEVE FOSTER, *Secretary.*

The subscription of each member is limited to one guinea.

The following additional names have been received up to the 30th ult. :—

Collins, William Job, M.D.	1	1	0
Fletcher, Joseph	1	1	0
Fussell, Rev. J. G. C.	1	1	0
Hellman, Christian	1	1	0
Hennet, Follet Charles	1	1	0
Holden, Edward	1	1	0
Holden, Isaac	1	1	0
Jones, Rev. William Taylor.....	1	1	0
Lutwidge, R. W., Skeffington	1	1	0
Nash, Edwin	1	1	0
Nicholay, John Augustus	1	0	0
Pakington, J. Slaney	1	1	0
Ruff, Edward	1	1	0
Shillito, George	1	1	0
Smyth, Samuel R.	1	1	0
Tucker, Henry	1	1	0
Ward, John	0	10	6
Whitworth, Joseph	1	1	0
Widnell, Henry	1	1	0

**THE NATIONAL MEMORIAL TO THE
PRINCE CONSORT.**

Lieutenant-General Grey has received the commands of the Queen to acknowledge the receipt of the report of the Committee appointed to give Her Majesty their assistance in the consideration of questions relative to the National Memorial to the Prince Consort.

Her Majesty has directed that her best thanks may be returned to the Committee for the valuable services which they have rendered and the advice which they have submitted to Her Majesty.

The Queen very fully participates in the regret expressed by the Committee that it has

been found necessary to abandon, for the present, the idea of the Central Hall, which, combined with a personal Memorial, would have appeared to unite the tribute of national gratitude with the objects in which the great and good Prince took the strongest interest, and would also for ever have associated with the Memorial the recollections of the Exhibition of 1851. This regret is, however, modified by the expectation that whenever the Commissioners of 1851 may be in a position to appropriate the vacant space north of the conservatory in the Royal Horticultural Gardens to the purposes for which the estate was purchased, a Hall may still form part of the buildings to be erected there.

The personal memorial to the Prince was always the first object, and the Queen never contemplated the combination of the Central Hall until that was adequately provided for.

Under these circumstances, the Queen is happy to see that the Committee have recommended for selection the design of Mr. Scott, to which Her Majesty had already given the preference among the many beautiful designs submitted for her judgment.

Windsor Castle, April 22nd, 1863.

Sir Charles Eastlake, F.R.A.

THIRD REPORT OF THE PRINCE CONSORT MEMORIAL COMMITTEE.

TO THE QUEEN'S MOST EXCELLENT MAJESTY.

We, the members of the Committee appointed by your Majesty to consider the best means of giving effect to your Majesty's wishes in respect to a Memorial to his Royal Highness the Prince Consort, humbly beg leave to report to your Majesty the result of our further proceedings with reference to the matters committed to us.

In our second report, dated the 27th of June, 1862, after referring to the difficulties which had compelled us to abandon the scheme of an obelisk, and to your Majesty's wish, communicated by a letter dated the 19th of April, 1862, from Lieutenant-General the Hon. Charles Grey, that we should turn our attention to some other mode in which the great object in view might be more satisfactorily effected, we stated that, in reviewing the various suggestions that had been made, we had become aware that a large proportion of the public appeared to be desirous of connecting the intended monument with some institution intimately associated with the Prince's name. We stated that a reference to his Royal Highness's recorded declarations and views had led us to conclude that there was nothing he had more at heart than the establishment of an institution for the promotion, in a largely useful sense, of science and art as applied to productive industry.

In considering the question of the site and special services of a building applicable to such objects we could not hesitate to express our opinion that the ground purchased with the surplus funds of the Great Exhibition of 1851—on which various establishments connected with art and science had already been placed, under his Royal Highness's auspices—would be the fittest for such a building; and, still guided by the Prince's wishes, as stated in the second report of the Commissioners for the Exhibition of 1851, we came to the conclusion that the most appropriate structure would be a Hall, forming a centre of action for men of science and art, where the

results of their labours would be communicated, while, to use the words of the Commissioners, it would at the same time afford "the means of establishing the connection between them and the public, which would secure permanent relations of reciprocal interest."

In obedience to your Majesty's suggestion, communicated in General Grey's letter above referred to, we then sought the advice and assistance of some eminent architects. The following were those to whom we applied:—William Tite, Esq., M.P.; Sydney Smirke, Esq., R.A.; James Pennethorne, Esq., Philip C. Hardwick, Esq., Thomas L. Donaldson, Esq., George Gilbert Scott, Esq., R.A., and Matthew Digby Wyatt, Esq.

Those architects, in a letter dated the 5th of June, 1862, addressed through Sir Charles Eastlake to the Committee, expressed their opinion that the fittest site for the proposed Hall of Science and Art would be the vacant piece of ground at the northern boundary of the estate of the Commissioners for the Exhibition of 1851. We were ourselves enabled to state that the Commissioners, on their part, were pleased to express their readiness to reserve, for a reasonable time, a suitable site for the Hall, of the extent required.

In the proposed general arrangements the effect of the whole, as pointed out in our former report, would in a great measure depend on the straightening of the public road, in itself a considerable improvement, but which could only be effected by taking a few feet from the park. This object, trifling as is the proposed alteration, could only be obtained by an application to Parliament for its sanction. A reference to the subjoined plan will explain the nature and extent of the proposed alteration.

After consulting further with the architects referred to, we decided that the Memorial itself, with which the proposed Hall was to be associated, should be placed opposite the centre of the area to be occupied by the Hall, but on the higher ground north of the Kensington-road.

Having thus endeavoured to reconcile the original and primary object of a Memorial with the erection of a building in its immediate neighbourhood applicable to those especial objects which his Royal Highness the Prince Consort had been anxious to promote, we proposed, in our second report, to invite a certain number of architects to furnish detailed designs for the Memorial, with sufficient indications (as we afterwards explained) of the relative position, extent, and character of the Hall.

Your Majesty's "entire and cordial approval" of the scheme above described, and of the course proposed to be adopted, was communicated in a letter dated the 18th of July, 1862, addressed, as before, by General Grey to Sir Charles Eastlake.

The architects whom we invited to furnish designs were the same whom we have before consulted. Two of the number—Mr. Tite and Mr. Smirke—having declined the invitation, we addressed ourselves to Charles Barry and Edward M. Barry, Esquires. Those distinguished architects having accepted our conditions the proposed number of candidates remained unaltered.

The architects originally consulted by us did not omit to observe, in their letter dated the 5th of June, 1862, that "the sum available for the Memorial is supposed to amount to between £50,000 and £60,000, which probably would not be more than sufficient for a work of art worthy of the nation, including the cost of forming a site to receive it."

On our own part, in our invitation bearing date the 19th of July, 1862, to the seven architects, five of whom had affixed their name to the letter above quoted, we adverted to the same condition by reminding the candidates that one important consideration would be "the amount of the fund which may be available for the cost of the Memorial itself, for that of the proposed straightening of the public road, for the arrangement of the area in Hyde Park with its decorations, and if possible, for the Hall on the south side of the road."

The various designs were submitted in February last to your Majesty's inspection.

The ability, ingenuity, and taste displayed in all the designs are such as to prove the wisdom of the course suggested by your Majesty, and we trust that on future occasions, in questions relating even more directly and exclusively to sculpture, it will be found advisable to consult those whose studies and practice lead them to regard monumental works with reference to the site they are to occupy, and in relation to surrounding objects.

At the same time we are aware, on the one hand, that designs for statues or groups of sculpture by architects can only be required to indicate the position and dimensions of such works, leaving the sculptors themselves uncontrolled in all other respects; and, on the other, that the judgment ought not to be influenced by any defects of detail in such necessarily vague representations of sculptured forms.

In proceeding to the onerous duty of pointing out designs, one of which might, subject to your Majesty's approval, and with due modifications, be chosen for execution, we had to bear in mind the amount of the funds subscribed as compared with the estimates of the candidates. As regards the Hall, we had, in our second report, before referred to, stated that we could do no more than express our earnest hope that sufficient funds might be provided to insure its completion. What effect the announcement of a definite scheme and chosen design may produce we cannot anticipate, but we are bound to state that at this moment the amount subscribed barely exceeds £60,000. We have to add that the estimates which the candidates have submitted for the Memorial, irrespectively of the Hall, are, with one exception, larger—in some instances considerably so—than that sum.

Before submitting our opinion on the relative fitness in other respects of the designs we prefer, it may be necessary to advert to the general question respecting the durability of statues in the open air in this country. We observe that those architects who propose that the principal sculpture they have introduced should be of white statuary marble have placed such works within a building. Bronze, with or without gilding, and in some cases Sicilian marble (which latter it is assumed is durable even when exposed to the atmosphere), are the materials selected for external decorations in sculpture. We are of opinion that in any case, even including architectural details, the surface of the Memorial and its accompanying decorations might require to be cleaned from time to time; and that, assuming bronze to be preferred, a light colour might be adopted, and by such precautions might probably be preserved.

Next to the apparently indispensable condition of an estimate for the Memorial within the means hitherto contributed, we were disposed to consider the designs with reference to the important question of due connexion with the site and proposed structures on the opposite or south side of the Kensington-road. The ground gradually rising from the south points out a commanding site for the Memorial, and suggests a definite termination not only to the portion of the site in the Park, but to the whole area on the south side of the road, with the buildings now or hereafter to be comprehended in the estate of the Commissioners for the Exhibition of 1851. The Memorial, we conceive, should, in an architectural sense, be in intelligible relation and connection with that estate, in itself a monument of the Prince's efforts for the promotion of Science and Art; and as occupying the highest point in the ground, considered as a whole, should, in its mere plan as well as in due elevation, have the character of a boundary adorned with a fitting monument.

We are of opinion that, in its general conception, the design by Mr. Philip C. Hardwick exhibits an especial attention to these requisites.

In considering the general character of the different designs for the Memorial we find admirable suggestions for structures partaking of the nature of a mausoleum. But we conceive that the Memorial in the neighbourhood of institutions which, with regard to their present and

proposed objects, exemplify the labours of the Prince for the public good, should rather convey the impression that it is a public tribute to his great qualities; and that while the proposed Hall of Science and Art would represent in the most general form the useful objects which his Royal Highness promoted, the Memorial itself should be essentially a national testimonial.

We, therefore, recur to the idea, that has been prominent at all times among civilised nations, of a statue in a conspicuous situation, sufficiently large to form, in reference to that situation, a commanding point of attraction, and with becoming accompaniments at different heights to enrich the mass and sustain the impression intended to be conveyed.

These conditions appear to us to have been carefully borne in mind by Mr. Hardwick; and, as regards the important question of expenditure, his is the only design according to which the Memorial itself, irrespectively of the Hall, could be executed at a cost within the amount subscribed. At the same time, we are of opinion that the Hall forms so essential a feature of his general plan that its omission would greatly detract from the merits of his design.

We now proceed to notice, as especially worthy of your Majesty's favourable consideration, a magnificent design, by Mr. Scott, for a Gothic Cross, the statue being within the structure, but open to view, and, in a great measure, open to the air.

In the letter of the architects, in reply to your first invitation that they would favour us with their advice, among various kinds of ornaments which were by them considered objectionable, the Gothic Cross, if approaching the slender proportions of an obelisk or column, was included. We advert to this only to remark that, in the first place, Mr. Scott's design does not come under that particular description of structure; and, secondly, that in a letter dated the 9th of June, 1862, referring to the opinion above quoted, he claimed for himself perfect freedom of choice in the style of his design.

While admitting the somewhat sepulchral character of what are called Gothic Crosses, we cordially appreciate the feeling which led Mr. Scott to adopt in his design, to use his own words, "the style . . . of the most touching monuments ever erected in this country to a Royal Consort," and to give to an architectural structure the character of a vast shrine expressive of the value attached to the statue which it protects.

We, therefore, do not dwell on the objection, likely to be urged, of a certain want of originality in a monument of this kind, because we believe that the beauty of this example, if it could be carried into execution without sacrificing the richness and completeness of its effect, would abundantly compensate for any actual or imagined resemblance to other structures coming under the denomination of a Gothic Cross.

It will be observed that Mr. Scott's proposed monument is not essentially connected with any present or proposed buildings on the south side of the public road. But, inasmuch as it would correspond with the central line of the area on that side—the statue, of course, fronting in that direction—we conceive that the required connection might be sufficiently attained by the arrangement of the surrounding ground; and, although the isolated and independent character of the structure in itself would seem to fit it for any open situation, we by no means consider such a circumstance of sufficient weight to open again the question of site.

A Gothic monument in the position already assigned for the Memorial might, in the opinion of some judges, involve as a consequence that the Hall, if ever to be built, should be similar in style to the Memorial, and consequently, again, dissimilar from the buildings already in existence on the estate of the Commissioners for the Exhibition of 1851. We think, however, that the intervening space might be a sufficient reason for some change of style, if desirable, in the Hall.

Having noticed these general, but, as we consider, not insuperable difficulties, we come to a much more formidable objection: the cost of Mr. Scott's proposed Memorial, after reducing the height from 185 to 148 feet—an alternative proposed in his printed description—and not without some other changes, cannot, we fear, be estimated at much less than double the amount subscribed.

To this must be added that no calculation is made for the cost of laying out the ground (in this case an indispensable addition), nor for that of straightening the public road.

Under these circumstances we still think we are bound to submit our opinion, in the first place, as to the relative merits of the designs. That opinion, after a careful and repeated comparison of those designs, considered respectively of cost, is in favour of that by Mr. Scott. The difficulties which present themselves in regard to the estimate can only be met, first, by abandoning for the present the project of a Hall; and, secondly, by such an addition to the present available amount as would secure the completion of Mr. Scott's monument without sacrificing its chief characteristics.

It is not without extreme regret that we regard, even as a possibility, the indefinite postponement of a project which his Royal Highness the Prince Consort appeared so earnestly to contemplate. In relinquishing the objects of utility to science and art which the Hall and its accompaniments would have unquestionably promoted, and in recommending the adoption of Mr. Scott's design, we have the consolation of reflecting that we in some measure revert to your Majesty's original intention in proposing the erection of a monument, in the usual acceptance of the word, with groups of statuary round its base.

But, we repeat, even for the execution of such a monument alone the sum contributed will be insufficient. It would be unbecoming on our part to offer any suggestion as to the means by which that sum might be augmented; but we venture to think that the liberality of Parliament would not be appealed to in vain, and that by the aid of the House of Commons the monument would assume a character in all respects national, and thus be worthy of the Prince to whose memory it will be dedicated.

We beg leave to recommend that all the designs should be submitted to the inspection of members of the Legislature, and ultimately to that of the public.

We humbly subjoin, as an appendix, various papers referred to in this our report.

DERBY, C. L. EASTLAKE,
CLARENDON, WILLIAM CUBITT.

Westminster, March 25th, 1863.

TWENTIETH ORDINARY MEETING.

WEDNESDAY, APRIL 29, 1863.

The Twentieth Ordinary Meeting of the One Hundred and Ninth Session was held on Wednesday, the 29th inst., Sir Thomas Phillips, F.G.S., Chairman of Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Dickson, Lieut.-Colonel	{ 10, Stanhope-terrace, Hyde-
Lothian Sheffield	park, W.
Donaldson, Sir Stuart,	{ 22, Rutland-gate, S.W.
Bart.	
Guthrie, Thomas Anstey	{ 7, St. George's-terrace, South
	Kensington, W.
Maurice, Joseph	{ 3, Langham-place, W.
Stansfield, Josias Logan	{ Hersham, Surrey, and Reform
	Club, S.W.

The following Candidates were balloted for and duly elected members of the Society:—

Blore, John	{ 8, Michael's-place, Brompton,
	S.W.
Bolton, Thomas Henry ...	{ 14, Thornhill-crescent, N.
Boothby, John L.	18, Notting-hill square, W.
Chatfield, Frederick	12, Pall-mall, S.W.
Clarke, Joseph, F.S.A. ...	13, Stratford-place, W.
Clement, John H.	{ 3, Gloucester-terrace, Church-
	street, Kensington, W.
Freyberg, James	{ 11, Grosvenor-street West,
	Eaton-square, S.W.
Waters, Robert S.	St. Giles, Dorset.

The following Institutions have been received into Union since the last announcement:—

Hackney Working Men's Institute.
Oldham Science School.

The SECRETARY called attention to a new form of barometer exhibited by Mr. Symonds, of which a description will be found at page 419.

The Paper read was—

THE VARIETIES OF COMBUSTIBLE MINERALS USED ECONOMICALLY, CONSIDERED IN REFERENCE TO THEIR GEOLOGICAL POSITION AND RELATIVE VALUE FOR CERTAIN PURPOSES.

By PROFESSOR D. T. ANSTED, M.A., F.R.S.

The use of combustible minerals for various economic purposes certainly dates far back in history, and is traceable, in various ways, even to times to which history does not refer. I have myself seen in Hungary, at various points on the outcrop of a very important seam of coal that does not appear ever to have been worked, clear proof that the coal has been removed from the crop and burnt in large quantity, the shale beneath being reddened and converted into brick. That this was systematic, and not accidental, there is ample evidence. The Chinese, also, have in this, as in many matters, antedated the discoveries of European nations. Still, however, so far as any important result is concerned, the whole economic history of combustible minerals lies within a very narrow compass, and hardly exceeds three centuries.

The one name Coal, has been popularly applied to all mineral substances that can be used for heating purposes, and that will continue to burn, and serve as fuel when once ignited, without being constantly fed with other combustibles. Sulphur and phosphorus are excluded from the list, owing to their deleterious properties and low heat of combustion.

It is to be regretted that the name Coal has not been more limited and more correctly defined, for it is well known that, both geologically and economically, there are many such minerals, some of which are admirably adapted for fuel, others yield excellent gas, others supply oils of various kinds, others are useful for pavement, and some are rarely employed except for ornamental purposes, as gems, or pseudo gems. All these are combustible minerals in some sense. A certain part of all of them consists of carbon—a certain part is earthy mineral, that will not burn; a part of most of them is hydrogen and oxygen gas, and most of them contain more or less water, so intimately mixed, that it cannot be got rid of by air drying; their respective properties depend on the proportions according to which the various component parts exist, and it seems possible, and is certainly very convenient, to separate them into several groups, bearing this in mind.

In the following remarks, then, I shall speak of (1.) Anthracite, meaning the varieties of combustible minerals

that consist of carbon only, with no appreciable percentage of hydrogen or oxygen. (2.) Coal, including those that contain so much hydrogen and oxygen as to burn freely with flame, but so little water and ash that they are available for getting up steam. (3.) Lignite, the varieties of coal in which the percentage of water is so large as to affect their value seriously as a fuel. (4.) Bituminous shale, including those mineral admixtures of clayey matter with carbon and hydrogen that are valuable for gas, and for distilling, especially at low temperatures. (5.) Mineral Oil, Bitumen, and Asphalte, names given to certain combinations of hydrogen and carbon, very abundant in certain localities, and recently found in large quantities in North America, but which, from their becoming fluid either at ordinary temperatures, or when heated, cannot be regarded as fuel in any proper sense. Some, as the asphalts, are used for pavement; others, such as mineral oils, are chiefly valuable for distilling.

1. **ANTHRACITE.**—This substance is abundant in some parts of the North Welsh coal-fields, and abounds also in parts of the great North American coal-fields. Often almost pure carbon, or, at least, as free from foreign ingredients as fine diamonds, and more so than graphite, it is yet a true coal, and has certainly been accumulated in the same way as the ordinary coal of commerce. There is an intermediate condition between it and bituminous coal, known as steam coal. The texture of anthracite is often loose and rotten, but sometimes very compact; it even assumes an imperfectly crystalline state; it does not take fire readily, and hardly keeps up its own combustion. Burning with intense local heat, it radiates heat badly, and is difficult to use either in the furnace of a steam boiler or in iron making. For either purpose it requires a special adaptation of the furnace, and a strong draught that would be unfit for coal. It demands, in fact, a large and rapid supply of oxygen gas, and this, combining with the carbon, forms carbonic oxide. Much carbonic acid gas is given off during combustion. Still, though long objected to, anthracite has made its way surely enough, and is now always used when other fuel cannot be got in abundance, that is, either more cheaply or more conveniently. Geologically, anthracite occurs very distinctly amongst the coal measures, though often below them. There is little probability of its having been formed or modified by the local application of heat to beds that have once been coal. The complete absence of free hydrogen gas and water in it must be accounted for in other ways than by assuming it to be half-burnt, but the chemist has not yet explained to the full satisfaction of the geologist what theory is the best and most probable. There is no very special use of anthracite; none, that is, for which it is better adapted than other varieties of coal. It is certain that a much larger proportion of anthracite occurs in the coal measures on the American than on the European side of the Atlantic.

2. **COAL** is by far the most abundant, the most valuable, and the most important of the mineral combustibles, but as it is well-known and has often been described, and the statistics of its extraction and consumption have recently been given to the Society by Mr. Hunt, I do not here intend to give any further details. Exceedingly abundant, and much worked in England, Wales, and Scotland, it is also plentiful in Belgium, Prussia, and France; there are large deposits in Spain, and it is even more widely-spread and more conveniently worked in North America than in Europe.

The varieties of coal are many, from steam coal, which connects it with anthracite, to jet, which is a variety of lignite. Chemically it is a compound of carbon and hydrogen with oxygen and nitrogen gases, sulphur, and earthy ash, chiefly consisting of silica. Coals containing little hydrogen, but still burning with some flame, are called steam coals. They are valueless for gas. The coals readily converted by partial burning in a closed retort into the substance called coke, contain

generally from 10 to 25 per cent. of volatile substance expelled in coking, and yield a fair supply of gas. The Newcastle varieties in burning become soft, swell and cake together; they are thence called caking coals. The Midland varieties retain the form of the coal during burning. Those varieties that contain least sulphur make the best coke. The varieties richest in volatile substances are used chiefly in gas making, but in proportion to their excellence in this respect, they fail in heating power. The best of these are of closer texture and finer grain than true coal; they do not soil the fingers, and they are compact enough to admit of being sculptured into ornaments. They are known as cannel coal. Beds of this kind occur among true coals with ordinary varieties of coal above and below them. They are of the usual thickness of the other beds of the district, and differ from them in no respect but in this superabundance of gaseous matter and capacity for different economic treatment. In Scotland they are called parrot.

Coal occurs in the British islands more abundantly in rocks of a certain geological date than in any others, and this position has been apparently so far confirmed by the principal beds worked for many years in other European countries, that geologists have sometimes assumed that more favourable conditions existed for the production of the mineral at that period than before or since. A marvellously rich tropical vegetation, owing to a higher temperature of the whole globe, an unusual amount of carbonic acid gas in the atmosphere, favourable to vegetation but unfavourable for the higher animals, and rapid movements of the surface at that ancient period, have all been assumed as characteristic of the coal period. Arguing from imperfect evidence is, however, always dangerous, and has generally proved unsound. More recent observation has shown that, not only is there good coal of much older date than the oldest part of the carboniferous period, but that almost all the rocks of the secondary period contain it in one part of the world or another; and my own investigations have recently laid open a coal field of undoubted excellence and very considerable magnitude, in the east of Europe, belonging to the tertiary period.

This observation of a sound tertiary coal in Transylvania has led me to the general consideration of the subject which I venture to offer to the Society in this communication. I will not here give the geological detail, which more fitly belongs to another place, but I may assure the Society that the fact is beyond a doubt.

Since, then, there is Liassic and Oolitic coal in very large quantity, some of it in England, although chiefly in the east of Europe, and in Virginia, in North America; since, also, there are deposits of true coal in the newer secondary rocks of the age of the chalk, and good beds also of true coal of the Tertiary period, it is quite clear that there can be no necessity to resort to extraordinary conditions of the earth and its climate to account for the formation. Wherever and whenever large quantities of vegetable matter have been accumulated and covered more rapidly than they have decayed, there seams of fossil vegetation have been produced. Where also the chemical conditions have been favourable there have these seams been converted either into coal or such variety of mineral combustible as we find to represent it. Whenever the undulations of the surface were favourable to the successive accumulation of deposits of this kind by a general depression, the beds formed have been preserved.

3. **LIGNITE.**—Very frequently, especially in the deposits of the secondary and tertiary periods, the process of change from rotten vegetation to coal has not been complete, and has produced only the material called lignite. By lignite I understand all those varieties of combustible that contain a definite per centage of water, and that when exposed to the weather for some time, break up into fragments, and ultimately fall to powder. It is assumed, but it is by no means certain, that these would ultimately be converted into coal.

Most, but not all of the lignites contain a large per cent-

age of ash, but this is an accident. Many of them resemble wood in texture; others remain in thin leaf-like layers, while a few varieties strictly and accurately resemble the best coal when they are first taken out of the earth. The test of time however never fails to bring out the truth; nor does it take long to apply the test, for the dirty appearance lignites soon offer is a certain indication of coming change. In practice, the water they contain greatly interferes with their use, for a certain portion of the really valuable part of the fuel must be consumed to convert this water into steam, and thus there must be a deduction made both of this quantity, which is altogether wasted, and also of the whole weight of water and ash contained, before the available per-centage of useful combustible is ascertained for practical estimate. The heating power even of the best of the lignites is thus very low compared with inferior coals. It is to be regretted that this, which is the only true practical distinction between lignites and coals, should be lost sight of by some geologists who have denominated tertiary and even secondary coals lignites, simply from their geological position.

The chief use of all the varieties of combustible mineral we have hitherto been considering, is either for fuel, or, by destructive distillation, for gas making; and the varieties yielding the largest per-centage of gas are generally the least fitted for fuel, *ceteris paribus*.

4. BITUMINOUS SHALE.—We come next to a class of minerals intermediate in their nature, containing much carbon and much hydrogen in their composition, although these elements are not combined to form true bitumen. These minerals also contain so large a per-centage of clayey substance that they belong to what geologists call shale, rather than to coal. There are many kinds known. The richest are found in Scotland, with and amongst coal; and it is not unlikely that some of the partings between coal that have often been thrown away as worthless, are of the same nature. Under various names, such as Boghead coal, Torbane-hill mineral, and many others, these have become familiar and important, owing to the introduction of a method of distillation at comparatively low temperature, originally introduced in France more than 30 years ago. Owing to the poverty of the shales made use of, the inventor of this method struggled for some time with little success. About twelve years ago the same method was introduced into Scotland, by Mr. Young, and the result in the case of the exceedingly rich shales named above was found sufficiently important to enable that gentleman to acquire rapidly a large fortune. The minerals in question lie on the border-land between coal and shale. Some of them pass into coals, and samples might easily be obtained which burn like coal. Others are much poorer and unlike coal in all respects, but it is very difficult, if not impossible, to draw a line that shall separate the two classes of minerals. All agree, however, in refusing to coke, and in retaining their slaty character after burning. The existence of a very clear passage from mere mineral oils through the shales that most resemble coal to those containing less than five per cent. of oils of all kinds on distillation, would not be difficult to make out. I have myself seen some such passage in the varieties here stated, namely:—

1. American rock oils—Canadian mineral oils.
2. Trinidad pitch, or bitumen. Rangoon naphtha—Pitch of Zante.
3. Chapapote of Cuba. Albert coal of New Brunswick.
4. Torbane-hill mineral.
5. Boghead and other rich coal-like Scotch minerals.
6. Cannel or Parrot coal, of Lismahago, and elsewhere.
7. Rich bituminous shales of Autun and other carboniferous rocks.
8. Poor bituminous shales of Autun and elsewhere, from the coal measures.
9. Posidonia shale and other lias shales, brown and black, but all bituminous.

10. Bituminous schist of Mansfeld, loaded with fossil fish. White paper coal.
11. Dorsetshire shales—Kimmeridge coal, &c.
12. Cretaceous shales, in the Ionian islands of Santa Maura and Zante.
13. Tertiary shales, brown coal and paper coal, used in Germany.

There is not one of these varieties of mineral (all available for the same purpose) that is not really distinct from coal in essential points, but some of them seem to pass into true coal much more completely than others. Thus, the cannel coals more especially might practically be regarded as one or the other—coal or shale—almost according to the use required to be made of them. On the other hand, the lignites, and brown coals of the tertiary period, and some of the lias shales, although actually distilled to profit for various kind of oils and paraffine, bear so little resemblance to any kind of fuel that they could never for a moment be mistaken for fuel, and as a matter of fact never have been so regarded.

5. BITUMENS.—But in the list of minerals just given there are included several that are equally little to be regarded as bituminous shales. They are in fact bitumens. Of these, the rock oils of America, not long since the subject of a description in this place, are among the most remarkable. The mineral pitch of Trinidad and Zante, and the Rangoon naphtha are only slightly less valuable. The remarkable Albert coal and the Cuban chapapote, are also examples, rather of bitumen than of bituminous shales, though the latter less perfectly than the former. The per-centage of foreign matter in some of these is comparatively small, and their analyses agree in some points not unimportant. The Albert coal I have not myself seen *in situ*. It has been well examined and described in the Journal of the Geological Society. The chapapote I have seen underground. It is a singularly irregular deposit, and cannot be regarded as regularly bedded. It resembles the examples of bitumen occasionally found in hollows and veins, in the older sandstones and in the old limestone rocks of England and Scotland. It does not retain either its thickness or mode of development to any distance. Like the irregular deposits of asphalt occurring amongst loose sand, it seems to have a very different origin from coal, and may have been conveyed for some distance in a liquid state.

Such are the principal varieties of combustible mineral. Many that were once regarded as of little value are now recognised as extremely useful, and are largely imported, or are used where they are found. Hardly one exists that does not possess some special value and some use for which the rest are less available. But, certainly, after the common coals used for fuel and gas-making—the shales from which light illuminating oils, heavier oils, lubricating oils, and paraffine, can all be obtained, are among the most interesting; they are also the least known.

It is certain that the slaty and stratified minerals, capable of distillation for these very useful purposes, are not strictly bituminous. The term bituminous shales is familiar, but not correct, since no bitumen, properly so-called, is contained in them. They agree, however, in yielding valuable hydro-carbons by a process of distillation now familiar enough; and in this they agree with some of the bitumens properly so called. It has been proposed to call them pyroschists, but this name is, I think, yet more objectionable.

In directing the attention of the Society to the subject of shales valuable for distillation, I would point especially to the considerable number of substances of this kind that exist, most of which are still untried. I believe the partings of coal seams, the tough brown and black shales of the old red sandstone and Silurian periods, and the so-called bituminous schists of many of our own rocks, many of them not highly coloured, may prove extremely valuable. Some of them would probably fail, but the means

of ascertaining their value are neither troublesome, tedious, nor costly.

I would here point out that it is hitherto chiefly the black schists, about whose value there can be no doubt, rather than those that apparently occupy doubtful ground between coal and shales, that have been used for slow distillation on the Continent; while only the rich and remarkable Boghead and Torbane-hill minerals have been extensively employed in the British Islands. It is not everywhere that such rich or profitable minerals can be found, but valuable results might perhaps be obtained from minerals that have not yet been much thought of. In this case, as in the case of iron ores, there are many very unpromising materials that turn out when examined to be the most valuable of all.

Having endeavoured to place before you, in some order, the various combustibile minerals that have been used economically, let me next allude to the geological position occupied by them. This is the more desirable, as by geology only are the localities to be known where similar valuable minerals may be looked for.

There is no doubt that the coal measures have hitherto yielded the most numerous and the richest bituminous shales, as well as the largest and most valuable supplies of coal. It is equally certain that in England the deposits of this period are most likely to retain their reputation in all these respects. Anthracite, steam coal, bituminous coal, cannel coal, Boghead and Torbane hill minerals, are all of the same age. But, although this is the case in England, and, to a great extent, in Belgium, Prussia, France, Spain, and Bohemia, and in the chief American coal fields, there are still marked differences in the position of the different minerals, and there are wide and important deposits of coal, some older, and others much newer. The Indian coal fields are probably very new. The Virginian coal field have long been known to belong to the secondary period. There are excellent lias coals worked in various places on and near the Danube, in Hungary—there are cretaceous coals in Hungary, and excellent tertiary coal as well as lignite in the same country. It is also remarkable that, although in England and Scotland the valuable and rich bituminous shales are close to the coal, in France and elsewhere they are often altogether removed. The great deposits of bitumen in North America are below the bottom of the whole series. Rich beds of shale, yielding fifty per cent. of all kinds of oil, near Antun, in France, are far above the highest bed of coal—the Lias bituminous shales are quite unconnected with any workable coal seams, and so are those of tertiary age on the Rhine. There is, then, no geological limit of the age for these minerals; neither is there any limit of colour and appearance. Many of the blackest shales are worthless, and some that are of a very pale brown are very rich—experience and analysis are required to form an opinion in any particular case.

The relative value of the combustible minerals, of all of which carbon forms a large proportionate part, is not, on the whole, difficult to determine. Pure carbon does not afford the best fuel. Pure, or nearly pure carbon, such as is seen in some samples of anthracite, is, indeed, a very difficult and unmanageable combustible, and can hardly be regarded as an economical fuel at all. A very strong draught, or mixed gases supplied rapidly, are necessary to enable it to continue burning when once heated. A coal containing a moderate per-centage of oxygen and hydrogen gases, and a reasonably small per-centage of ash, is the best for all purposes as a combustible. Some kinds, especially of the Newcastle coals, cake, or run into a kind of slag while burning; other kinds, such as Yorkshire and Lancashire coals, burn through without caking, and fall to a white and red loose powdery ash. None of them, however, retain their exact form when burnt, either in an open fire or in a retort.

Most of the cannel coals, and those varieties called Boghead coal, and Torbane-hill minerals, are very

valuable for distillation of all kinds, but they retain their form, and behave like slates in the retort. Some of them, however, are capable of being used alone as fuel. They are all especially rich in gases, paraffine oils, and lubricating oils, but their peculiar value in this respect is accompanied by a corresponding diminution of their value as true coals. The lias coals of Europe and America, the oolitic and cretaceous coals, and such tertiary true coals as are known, all resemble rather the Yorkshire and Lancashire varieties than the caking coal of Newcastle. Most of the French coals and many of the Belgian varieties are of the same kind. It is difficult to draw an exact line that shall separate the true coals from the richer, blacker, and more coal-like shales used for obtaining gas or paraffine oils, but it has long seemed to me that the slaty character, recognised in burning, affords a good practical definition.

Regarded as fuels, all the coals are exceedingly superior to lignites, for the reason already given, namely, that the coals are almost entirely without hygroscopic water, while the lignites, without exception, contain a marked per-centage. Much of the value of lignites is abstracted by the inevitable necessity of evaporating off this water before the rest of the material can come into use as a combustible. It is, however, clear that this is no very serious disadvantage when the object is to obtain the oils by slow distillation, and thus some of the poor paper-coals or tertiary shales of Germany have been used with fair result for this purpose, although utterly unfit for fuel, while the richer shales attain a value very far exceeding that which could belong to them as combustibles. Still more are the non-combustible bituminous schists inferior to coal as fuel, though they possess great value for the purposes for which they are specially adapted. It is to obtain a more general recognition of this value, and as a suggestion to those who are in the way of discovering available minerals of this kind, that I have chiefly been induced to bring forward this subject to-night. The minerals that may thus be used are so numerous, varied, and widely-spread—many of them are so unlike combustibles, and the results obtained from them are so immediately valuable, that they may almost be regarded as a new source of mineral wealth. As, in the case of iron, we are now employing numerous varieties of ore formerly neglected and despised, so I feel that the time is not far off when the collection of shales for distillation will be an important occupation, not only in the British Islands, but in most other countries. Bituminous shales are far more common than is generally thought. In limestone countries they are rarely absent, and they are hardly less frequent associated with clays.

It is a point of considerable importance that some of the lignites may also prove available for distillation, but of this there is at present hardly sufficient evidence. The assistance of the chemist is required to determine how far the varieties that are most abundant are available for this purpose, and whether some modification of the process or the addition of some ingredient may render profitable operations at present not worth carrying on. The demand for light oils, for illuminating purposes and for paraffine, seems only limited by the price, and the manufacture is extending in most countries of Europe. It is certain that there is no geological period and no rock that may not contain useful minerals of this kind.

Mineral oils and true bitumens are less common than bituminous shales, but they also are more widely dispersed than is generally thought, and when found in large quantity they possess great value. Some are obtained from considerable depth, and are very tenacious; others, as naphthas, are thin and float on water; some occupy definite geological positions in certain rocks, while a few, comparatively rare, offer peculiar mineral combinations, and are found described in mineralogical works by special names.

I have recently visited one of the localities where such bitumens occur in considerable quantity, and as it is not

in many places that the conditions are so simple, I will briefly allude to them. I speak of the pitch wells in the island of Zante. This island, like all the other islands off the west coast of Greece and Albania, and like the main land adjacent, consists almost entirely of limestone, with alternations of marl and gypsum. Limestone is everywhere at hand, and most of the hills—all the higher hills and mountains—are exclusively composed of it. But there is a volcanic band not far off, and the presence of sulphur is strongly marked in many places—in some by the mineral itself—in others, by sulphur springs—and elsewhere, by large deposits of gypsum—the carbonate of lime being converted into sulphate. There are also indications of bituminous shales in more than one of the islands.

The pitch wells of Zante are in a hollow, between hills of limestone, opening on one side towards the sea, on the south-west of the island. A very singular naphtha-spring occurs in a corresponding position at the north-east end. The latter locality is very inaccessible, and the quantity of mineral seems small, but the former springs are easily visited, and on rather a large scale.

The pitch or bitumen here comes near the surface in various parts of a boggy tract, barely above the sea level. The bog is intersected with wide drains, but wherever the ground is dug into for a few feet, there bubbles up slowly, but in considerable quantity, a thick bitumen, which can easily be removed, and is as rapidly replaced. It is too tenacious to rise readily above the water, but a little is constantly oozing, and there are large bladders of bitumen a few inches below the clear and perfectly pure water that seems to rise with them. Large quantities of this substance have been occasionally taken for local purposes or for ships' use, for which it seems well enough adapted without any preparation. It has been used in this manner for the last two thousand years whenever the island has been inhabited.

That this curious spring is connected with a bituminous deposit of some magnitude there can be no doubt, but the cause is not clear. It may be, that the bituminous shales cropping out on the flanks of the mountain of Skopo, on the other side of the Bay of Kieri, where there is also a large quantity of gypsum, may exist here in large quantity, and in a somewhat different state, the pitch-like substance there forming a bituminous shale being allowed here to ooze away in a half-fluid state. The limestones in this part of the world probably overlie large sheets of lava, through the crevices and fissures of which gases and vapours arise and affect the overlying rock.

As a general conclusion to the remarks I have offered to the Society in this communication, I would point out—First—That the variety of combustible minerals available for practicable purposes is large, perhaps larger than is generally thought, and that such minerals form several significant groups. Secondly—That they belong, all of them, to all geological periods, no one being of necessity limited to any part of the earth's history. Thirdly—That there is less advantage taken of many of them than their real importance deserves. And, Fourthly—That much has yet to be determined as to the circumstances under which the organic kingdom of nature has been enabled to provide these large stores of carbon and hydrogen as mineral contributions to the well-being of man.

DISCUSSION.

The CHAIRMAN had now to invite them to proceed to the discussion of the paper which had just been read by Professor Ansted, and he thought they would all agree with him that it was one of very great merit—almost a pattern for any scientific treatise, inasmuch as it dealt in the least possible degree with conjectures or speculations, and was reasoned out in a thoroughly scientific manner. Professor Ansted had called attention to what, no doubt, was a very interesting subject, viz., the existence of

bituminous schists, which hitherto had not been very much used for the service of man, and it might be that those schists would play as important a part in the history of economic production as coal itself had done. It was a very remarkable fact, and one which they did not sufficiently dwell upon, that coal had only been in general use for a very limited period. Even in the manufacture of iron coal was hardly used in the beginning of the last century, but now it was of enormous importance in its application to this industry. Similarly, coal was not used in producing the textile manufactures of this country till after the middle of the last century. Up to that time water power was the agent by which a very large proportion of our productive industry was obtained. Now, however, the use of coal had increased to an enormous extent, and had greatly enlarged the productive powers of mankind by means of steam. It was the great source from which the enormous productive energy of this country was derived. Its application they knew was almost universal; within the last two years it had been employed to produce many beautiful colours which were used for dyeing. It seemed difficult, in fact, to indicate any limit to its application. It was distributed from this country throughout the colonies, and indeed throughout the world. Extensive as were the deposits of coal in almost every part of the globe, English coal was sent to a very large extent—an extent which increased year by year—to other countries. This subject seemed to him to be one of abundant interest; and he trusted that the paper would lead to an animated discussion.

Mr. THOMAS SOPWITH, F.R.S., entirely concurred in what had fallen from the Chairman with regard to the merits of the paper they had just heard. He considered it to be quite exhaustive as far as it went, and to be, as it were, an index to one of the most important fields of observation that could occupy the attention either of that Society or of the public at large. A few hundred years ago coal was prohibited even in dwellings, and the Chairman had properly observed that it was only of late that its consumption had become so very important and general. The amount of that consumption was now very distinctly given in the statistics which were regularly published by the Department of Practical Geology, in Jermyn-street, under the direction of Sir Roderick Murchison, the mining statistics being placed under the able care of Mr. Robert Hunt, who had for a number of years succeeded in collecting a most valuable amount of information upon this subject. A great deal has also been done by that institution towards drawing the attention of the public to those various kinds of combustible minerals, from different districts, to which Professor Ansted had referred. Now, the question of coal, as regarded its conservation, was one which did not properly come within the province of the paper under discussion. That was another, but a very important, question, and he would only refer to it in this point of view—that he believed the great and increasing consumption of coal would very rapidly give the greatest importance to an accurate study of those numerous other minerals which had been referred to. He should think that the effect of the paper would be to draw the attention in many localities to this subject, and he would strongly recommend that in country places collections or museums of these minerals should be made, as they would be found objects of great local value, and of much interest to visitors. Probably, duplicates of the specimens exhibited might be sent to persons who would be willing to make experiments upon them, and he hoped these would be made with the same skill and accuracy as were employed on the building stone to be used for the Houses of Parliament. A commission was appointed by Government for the examination of every description of stone throughout the kingdom. Each specimen was subjected to analysis, and experimented upon as to its strength, absorption of moisture, and all other qualities. He believed that published experiments

upon materials such as those now before them would be very valuable, and that the subject was one well worthy the attention of Government, as well as of men of science. He did not know that it was possible to do more at present than to express the very high opinion he had of the able manner in which Professor Ansted had brought before them an epitome of this subject.

Mr. P. L. SIMMONDS said the subject so clearly and so ably brought before the members by Professor Ansted was one that ought to be fully and fairly discussed, looking at the great interests which were involved in the adequate supply of the combustible minerals. Important as were these interests, viewed only in a national point of view, to ourselves for the maintenance of that supremacy which had long marked our manufacturing interests, we were not the only country concerned in the question. All foreign countries, and our numerous and thriving colonies, were deeply interested in the present and future supply of carboniferous fuel. Moreover, the progress of steam navigation was so rapid all over the world, that a supply of steam fuel at various convenient coaling depots was of essential necessity. Steam had become either the prime mover or the adjunct in the greater part of our mercantile marine and Royal Navy, and was also spreading extensively among foreign nations and the various British dependencies. It was only in a few quarters like the North American rivers that wood could be obtained for steam fuel. Year by year our export of coal was increasing, and last year it reached 8,300,000 tons, of the value of 3½ millions sterling, and nearly two-thirds of this went to the Continent. In the ports of the United Kingdom alone the entries of steamers were nearly 9,000 annually, besides naval steamers; and our Australian and other colonies had now a very numerous steam fleet. The export of machinery and mill work to the amount of £4,000,000 annually, involved also the supply of a large amount of coal to keep them in action. The examination of combustible minerals in our colonies had not yet been so general or systematic as it might have been, but as most of these had now a competent government geologist, inquiries would no doubt be set on foot to ascertain the economic value of many of the lignites, shales, and schists which were to be found in them, as was evidenced by the admirable and extensive collections forwarded to the International Exhibition. In the instructions forwarded to the colonies, the desirability had been urged upon them of forwarding samples of coal in sufficient quantities to have their steam value tested at the Woolwich arsenal, and in the case of Vancouver, New South Wales, and Nova Scotia, this had been complied with, although he was not aware whether the reports of the trials and analysis had yet been published. Now that the economic value of very many of the bituminous shales for destructive distillation was better understood, and their products of such great commercial importance, a more general knowledge of the localities where they were found, and their universal character, was very necessary. As he saw present his friend Dr. Milligan, of Tasmania, he was sure that gentleman could furnish the meeting with some useful information on the coal formations and dysodile of that island. The limits of the great coal-field of New South Wales were at present imperfectly known; it was found to extend into Queensland, and to re-appear in Tasmania, but it had not been practically opened out in either of those colonies. The total produce of coal in New South Wales, in the last ten years, had been 1,780,000 tons, of which more than one half had been shipped to India, China, and the neighbouring colonies. The present appliances of the collieries at work, in the colonies were equal to the production and shipment of 20,000 tons weekly, the average price for good screened coal being 12s. to 14s. the ton. The further development of this great mineral resource, it was stated, was only arrested by the want of miners. If this want were supplied, there was no doubt that in the course of a few years the coal-fields of the southern hemi-

sphere would furnish gas and steam fuel throughout the Indian and Pacific Ocean. In conclusion he might state that a very interesting report on these coal-fields, by Mr. W. Keene, the government examiner, was published in the New South Wales Catalogue of the International Exhibition of 1862.

Dr. MILLIGAN said he should be very glad to give any information in his power respecting the coals of Tasmania, although as regarded the coal deposits of New South Wales he knew but little, excepting that the coals were good and existed in large quantities. In Tasmania they had got three or four different sorts of coal. They had a good bituminous coal, in seams up to thirteen or fourteen feet thick, on the east coast; and at the southern end of the island they had an extensive deposit of anthracite. On the west coast they had a jet-like lignite, which yielded a large quantity of gas, and burnt to a white flocculent ash, without leaving any other residuum. They had, also, besides, on the north coast, upon the River Mersey, seams of a shale nearly akin to dysodile, highly combustible, burning freely, with a very rich flame, and disagreeable fœtid odour, and yielding a very impure gas. Its combustibility depended, apparently, upon resinous matter imbedded in the shale—a resin which could be separated from the substance of the shale into innumerable fine granules by trituration and washing. It had not yet been applied to any economic purpose. Some oils had been experimentally distilled; but they could never be extracted on a large scale except for local purposes, as rock oils from America could probably be imported even to that distant part of the world cheaper than they could be produced on the spot. He ventured to say, that on the east coast, when the coal came to be thoroughly opened out, it would be found to be a valuable steam fuel. It was of the same age, whatever that might be, as the steam coal of Newcastle, New South Wales. The Rev. W. B. Clark, of Sydney, a well-known geologist, on examining the specimens of coals and associated shales from the east coast of Tasmania, pronounced the fossil impressions contained to be identical with those existing in the coal series of Newcastle, New South Wales. There was a very marked difference in the fossil impressions of the anthracite of the south, and the bituminous coal of the east coast, and he never found the anthracite beds associated with the latter, except on one occasion, when he met with one seam in sandstone of the bituminous series, on the east coast of Tasmania, and that was a purer anthracite than any other in the island. The coal beds had been very much broken up, in the centre and along the eastern seaboard, into isolated patches, by the eruption of greenstone. The principal seam of coal varied from eight to fourteen feet thick, and in one place, about thirteen miles from the sea, where the seam was twelve feet thick, and could be worked by an adit, an incline might be had from 1,200 or 1,300 feet of elevation down to the sea, along which the coal might be run with little difficulty. This, however, had not yet been entered into as a commercial undertaking. On the east coast, immediately upon the sea, and close to a shipping place, some new mines had lately been opened out, and he recently saw by the newspapers that one of them had been described by the Commodore on the station as a very promising coal for steam purposes, it having been tried on board his vessel. That at the Mersey River on the north coast was also a good steam coal. The anthracite at the southern end had not been used extensively for steam purposes, but it had been used in combination with wood, and found to answer well. In the immediate vicinity of Hobart Town there was a considerable quantity of coal; the seams, although not more than about twenty inches thick, covered a considerable area. He was not aware that he could add any more to what had been already said, except perhaps to mention the great number of parts, eastern and central, at which coal had been discovered. Coal mines extended from Hobart Town, more

or less, to the centre of the island. Northward, in the neighbourhood of Launceston, they had indications of the coal measures having been swept away by denudation. They occurred there, but not extensively. However, from the great number of places at which coal was found, he had no doubt, when thoroughly explored, it would be proved that Tasmania possessed vast resources in her coal fields, and that they would ultimately not only minister to domestic industries, but prove very valuable to the commerce of the empire in the long run.

Mr. PAUL wished to draw attention to one particular referred to by Professor Ansted, namely the essential characteristics and differences of those kinds of combustible minerals belonging to the carboniferous series. Taking, in the first place, those minerals commonly known as coal, there might be selected from among the numerous varieties certain of them presenting well-marked characters of difference. Thus, for instance, anthracite—the free-burning “steam-coals” of the Welsh coal-field,—the coals of the Lancashire district and Midland Counties, the caking coals of the Tyne district, and the cannel coals of Scotland. Between well defined specimens of these varieties of coal there were great apparent differences, but a closer examination showed that those differences were only in degree. Coals might be easily found which, while presenting all the apparent characteristics of anthracites, more closely resembled bituminous coal in their composition. Between the bituminous coals of the Tyne district and the “steam-coal” of Wales there was, in many instances, no kind of difference in composition. Between the cannel coals of Scotland and the bituminous coals of Newcastle, the difference in composition was small as a rule, and there were cannel coals which approximated more closely to the coal of Newcastle and Lancashire than they did to the better and more characteristic varieties of cannel coal. The term bituminous, when applied to coal in the sense of its containing actual bitumen, such as that of Trinidad or Jews’ pitch, was a false designation. The character properly denoted by the term bituminous, as applied to coal, was the existence in the coal of a portion of its substance which was capable of being volatilised by heat, and which, though it was not true bitumen, was analogous to bitumen. This character bore no recognisable relation to the amount of hydrogen in the coal; but coals differed considerably in regard to the amount of bituminous substance they contained. Thus, for instance, some of the well-known steam coals of Wales, such as the Resolven, Graigola, Merthyr, Llangennech, and others, were, in composition, almost identical with the Hartley coals. The really important practical difference between these coals consisted in their yielding different amounts of volatilizable substance when heated. The Welsh coals yielded but little; the Newcastle coals yielded half their weight in some cases. These volatile products, being swept away from the furnace before there was time for their being burnt and rendered available as a source of heat, appeared at the chimney mouth as smoke. Hence arose the difference sometimes found in the fuel value of these coals; for the volatile substances given off were difficult to burn, unless special provision was made for the purpose. It was owing to this circumstance that in the examination of coal for the Admiralty, the value of the Newcastle coals was placed so far below that of the Welsh coal. A mistaken system of trial was adopted; both kinds of coal were tried under the same conditions, whereas, if the mode of using the coals had been adapted to their peculiarities, a different result would have been obtained. The experiments subsequently made, at the instance of the coal owners of the Newcastle district, proved most conclusively that the Hartley coals had a higher fuel value than was assigned to them by the results of the Admiralty trials, and that they were, in this respect, equal, and in some respects superior, to Welsh coal. Throughout the whole range of varieties of coal, though it was possible to select typical specimens that were widely different, still no essential difference could be recognised. Between all of

those typical varieties there were intermediate varieties so numerous and presenting such minute gradations of difference, that it was impossible to draw any absolute line of distinction between them. It was very important that these facts should be borne in mind, more especially since it was convenient to use the term cannel coal, caking coal, free burning coal, &c., and to comprise the whole of the varieties of coal, excepting anthracite, under the term bituminous coal. The bituminous character of coal from the carboniferous series of rocks was a well marked feature of distinction from lignite, which, though it contained volatilizable substance, approximated more closely to wood in its nature generally, and in the nature of the volatilizable portion. Considering only the applicability of a mineral as fuel, it was equally impossible to establish any absolute distinction between coal and those minerals, associated with it, which were capable of being burnt, or which at least contained combustible substance; but which differed from what was practically recognised as coal, in containing a larger amount of earthy substance, and which were generally called bituminous shale. A mineral of this kind, containing 20 or even 30 per cent. of ash, might be used as fuel at the pit’s mouth, but it would not be sent up to London for use while other minerals could be got to send, that contained only 2, 3, or 5 per cent. of ash. In the absence of minerals of the latter kind, which were commonly called coal, and in the absence of other fuel, some of the bituminous shales, or such minerals as that of Boghead, might be used as fuel. Altogether the application of the term coal was merely conventional, and it was a convention determined altogether by circumstances. But from another practical point of view there were differences that had not hitherto been much regarded, and which might be made a means of determining a difference between coal and shale. It was, for instance, a recognised characteristic of coal, that it would leave when heated a fixed carbonaceous residue, called coke, amounting to a considerable portion of its weight. Coals varied very much in this respect; anthracite gave from 93 to 80 per cent. of coke. The Welsh steam coals gave from 10 to 70 per cent., while the Newcastle coals gave only from 70 to 60. The cannel coals gave from 60 to 40 per cent. The Boghead mineral gave 30 per cent. of fixed residue. But this mineral contained 22 per cent. of ash, while ordinary coal did not contain more than 5 per cent. of ash. Therefore, to find the difference between coals and other minerals, in this respect, the ash must be deducted, and the ratio of the fixed carbonaceous residue to the volatilizable portion ascertained. Then, there was a very marked difference recognizable. No true coal, as the term was generally understood, gave less than one-third its weight of fixed carbonaceous residue. Even the Albert coal of New Brunswick, which was in many respects an exceptional coal, containing less than 1 per cent. of ash, and being applicable for the manufacture of oil and paraffine, yielded 33 per cent. of fixed carbonaceous residue, and 67 per cent. of volatile substances. Newcastle coal would yield 66 per cent. of fixed carbonaceous residue, and 37 per cent. volatile substances. The cannel coals, on the average, would yield half their weight of volatile substances, and an equal portion of carbonaceous residue. But the Boghead mineral would yield 88 per cent. of volatile substance, and only 12 per cent. of fixed carbon. Here was a wide difference from coal generally, and even from cannel coal. Certain bituminous shales again, that were not used as fuel, but for the manufacture of oil by distillation, would yield from 80 to 95 per cent. of volatile substance, and only 5 to 20 per cent. of fixed carbonaceous residue. Among the shales here referred to there was one from Vouvant, analysed by Dumas, and worked by Selligue for oils and paraffine in 1833, and another, an English shale, analysed by Laurent, in 1833. It was a remarkable fact that the increase in the proportion of volatilizable substance, as compared with the fixed carbonaceous residue, bore a direct relation to the amount of earthy substance in the minerals. This was very noticeable in

some of the poorer kinds of cannel coal, containing a large amount of earthy substance, or ash. The greater the amount of ash, the greater was the ratio of volatilizable substance to the fixed carbon. In this respect the Boghead mineral appeared as far removed from ordinary coal as it was by the external characters it presented and the amount of ash it contained. It resembled bituminous shale far more than it did coal, and it could not be doubted that, by reason of these characters, it would not be used as fuel, nor would it be used at all if it were not for its capability of yielding gas and oil. Another difference between coal and the bituminous shale associated with it, consisted in the nature of the oily products obtainable from them by distillation, as well as their amount. For use as fuel, it was not a matter of any great importance what was the nature of the volatile products given off by a mineral, provided they were combustible and could be burnt. But as regarded the use of these minerals for the manufacture of oils, the nature of the volatile products, no less than their amount, was of paramount importance. Coal properly so called, yielded oily products that were different in kind from those yielded by bituminous shales and by the cannel coals that were most closely allied to bituminous shale. This was a most important distinction between them as regarded the manufacture of oil, and in reference to the question that had been raised as to whether the Boghead mineral was a coal or a shale. Judging from that character which rendered this mineral so eminently well suited for that purpose, it should unquestionably be regarded as a shale, and not as a coal, by reason of its far greater resemblance in that particular to shale than to coal. Considerable attention had already been directed to the use of bituminous shales for manufacturing oil from them by distillation. The first attempts that were made, long ago, to establish the branch of manufacture were made before there was any demand for the oils which were now so largely used as a source of light, and for lubricating purposes, and it was only since the use of these materials became general on the Continent, and a large demand for them had been created, that any attempts to manufacture them in this country proved successful. Now, the demand seemed to be limited only by the extent of the supply. This manufacture had been carried on since 1833, in France and in Germany, and it was now being prosecuted in the neighbourhood of Linlithgow, with some shales occurring at Broxbourne; and at several other places between Glasgow and Edinburgh there were works of a similar nature. As regarded the use of anthracite as fuel, the objections that were formerly found to obtain against it were only due to the misapplication of this mineral as fuel. Means had now been found of using it with success, and, in many instances, with great advantage, inasmuch as its large per centage of carbon rendered it highly valuable when intense heat was required. Bituminous coal, a century or so since, was objected to in a similar manner. People had been accustomed to use only wood-charcoal, and it was found that bituminous coal, used like wood-charcoal, was not suitable for smelting iron and other metals. But it was very soon found that this was only a consequence of improper use, and the right mode of application was soon learned. Now, as was well known, scarcely anything else was used as fuel for these purposes.

Professor TENNANT would like to say a few words upon the mineralogical part of this subject. The gentleman who had just spoken had been alluding to various substances which he (Professor Tennant) was enabled to exhibit. He first exhibited a piece of soft bitumen, so soft that he could stick a pin into it. It was something like india-rubber, and was a substance which could be obtained in large quantities on the rocks of England, it being very well known about Derbyshire. He then showed a piece of cannel coal, a very compact material, differing very widely from that to which he had previously referred. Then he had different specimens of anthracite, varying considerably with regard to their general characters. There were

also other materials, graduating down to the common jet, found in abundance in the lias of Whitby and that neighbourhood. Then they came to the different varieties of lignite. These materials had all undergone various changes. They were all deposits, many of them animal, mixed with a large quantity of vegetable matters. Some of them did not contain vegetable matter, but had been derived, as he believed, solely from animal. They had before them a mineral called albertite, from New Brunswick, a specimen exhibited in the International Exhibition. Just before that exhibition was closed, however, a gentleman of the name of Mackenzie brought several specimens from a place in Rosshire, and stated that he had found them whilst excavating for some railway works, and that the workmen had used it for cooking their food, and lighting them at their work. He (Professor Tennant), in company with the Rev. Mr. Honeyman, who was well acquainted with New Brunswick, examined the specimen with regard to its mineralogical character, and in all respects it agreed with that found in New Brunswick. They then compared its chemical properties, and found the result the same. Mr. Mackenzie had drawn up a paper on the subject, and had sent it to the Geological Society. In the Brazilian Court at the Exhibition, there were many specimens exhibited of those shale substances, which yielded oils in large quantities. In the Canadian Court, also, there were some valuable specimens in a geological point of view. He held in his hand one of the most interesting slabs that could possibly be exhibited. It was a specimen from the Collingwood district, and in it could be found the remains of 400 or 500 trilobites. There was one large slab in which there were thousands of them. In the Canadian court was issued a most valuable catalogue, which was given away to persons making application for it. He then exhibited a specimen of petroleum rock, from which oil had been distilled, showing its bituminous shales. In the catalogue a very full description was given, and he should recommend that that portion* bearing on the subject should be printed in the *Journal*. With reference to the coals exhibited in the Exhibition, there were some specimens of Borneo coal which he believed was from the tertiary period, samples of which might be seen in the Museum at Kew. It contained a large quantity of amber, resin, &c. He was extremely obliged to Professor Ansted for bringing this subject before them, and he regarded this paper as, in a commercial point of view, one of the most valuable they had had for some time. The paper read by Mr. Hunt some months since was also most interesting, in which he had spoken of the enormous value of our coal, amounting to fifty-one millions annually. It was very desirable that such subjects should be, from time to time, brought before the Society in the able manner in which this had been done both by Mr. Hunt and by the gentleman who had favoured them with the paper that evening.

The Rev. J. G. C. FUSSELL said Professor Ansted spoke of the desirableness of experiments being made in different parts of the country, where shales more or less promising, or rather unpromising, might occur. If he could give them one or two suggestions as to the best way of conducting those experiments, it might be of great assistance to them. If they had access to gas-works, would it be desirable to submit the specimens to the retort?

The CHAIRMAN then asked their authority to tender thanks to Professor Ansted for his valuable and interesting paper. Professor Tennant had called their attention to the enormous interests involved in the subjects introduced for their consideration by Professor Ansted, and he had mentioned a most stupendous fact—that the coal-mines amounted in value to £51,000,000 sterling. We now talked of millions very glibly, but our forefathers would have talked of them in a far different way, and

* See next page.

would have laid much greater emphasis upon the word. But really when they came to consider it, it was an enormous wealth to be produced by the coal mines of this country. And when they recollected, too, that those coal mines were not only so valuable in themselves, but that they really gave a practical value to all our manufactures, it did seem impossible to overestimate the importance of this topic. Certainly a very important feature in Professor Ansted's paper was that it partly related to non-combustible materials, or, at all events, to minerals not applicable for fuel, but still very important for distillation. This was scarcely a less important subject than the consideration of fuels, and he thought it must have interested them all. He would now ask them to do—what he was sure would give them great pleasure—to give their thanks to Professor Ansted for his valuable scientific paper.

Professor ANSTED would like to say a word or two in reply; and first of all with regard to the specimens exhibited. They were all of them worth looking into by anyone who took an interest in the subject, and was familiar with minerals of the kind. They were not intended to be examples of the best kinds of shales, but were from very interesting localities, and many of them from localities entirely new. As to the mode in which the shales which might be found in various parts of the country could be tested, in order to determine their value, he thought the wisest and safest way, generally speaking, was to refer at once to some respectable authority, to put the mineral into the hands of a chemist. If the matter was not worth the expense of a small practical analysis, it was not worth trying whether it was a substance of importance or not. In many cases, as would be seen by any one who looked at the specimens before him, the appearance of the shales did not agree with the value they possessed. It would be impossible for any person not exceedingly familiar with minerals of this class, to detect their real value for the purpose of slow distillation, which yielded the illuminating oils. He was quite aware, with regard to the definitions of those products to which Dr. Paul had alluded, that it was impossible to draw a line sharply. No one could be better aware of the fact than himself. He was glad, however, that Dr. Paul had directed the attention of the meeting to it. It was desirable to draw these distinctions as far as they could, and for that reason he had urged, in two or three places in the paper, the desirableness of defining certain terms in common use, such as bituminous shale, coal and shale, and so forth. He thought in most cases bituminous shale was sufficiently distinct from coal to justify its being called by that distinctive name. Coals of different kinds were too closely alike to admit of any names to distinguish between them. He did not wish to obtain any greater definition than the subject required; but at the same time he thought it as well they should define where they could, as in practice sometimes a great deal depended upon the use of the proper term. He was glad the paper he had been enabled to bring before them had met with their approval, and he hoped it would be found useful. Many people in the north and other parts of the country would be very much benefited if they were to look out for these shales, and get some one to ascertain whether they really contained a workable percentage of oils. There was no doubt this was a subject increasing in importance, and one which would go on advancing in interest.

Mr. WINKWORTH said, that being a director of a gas company in which was involved half a million of money in the production of gas in France, he thought it would be very desirable if they could find any cheaper material than coal, and if there were any means by which shales could be made available for the purpose of generating gas. He supposed if shales were used they would not be able to get coke as in the case with coal?

Professor ANSTED remarked that he was afraid it would always be the case with shales that they would leave no residuum of any practical value at all. In all the speci-

mens shown, the residuum was almost entirely a stone, and had no possible value for fuel purposes. That would put a stop to the use of shales for making gas in the ordinary way. Besides, it did not pay.

Mr. WINKWORTH said that in consequence of the mildness of the winter, coke had gone down so much in price, so much lower than ever before, that he could almost fancy it would answer their purpose to use shales, and put the coke question aside.

The Secretary announced that on Wednesday evening next, the 6th inst., a paper by Dr. Andrew Wynter, "On Bread-making, particularly with Reference to the Condition of those Employed in its Manufacture," would be read.

The following are the portions of the Catalogue of the Minerals of Canada referred to by Professor Tennant:—

PETROLEUM OR ROCK OIL.

1. Enniskillen, lot 16, range 2, Canadian Oil Company, Hamilton.

- a. Gum or mineral tar from the surface.
- b. Crude oil from the well.
- c. Refined or burning oil.
- d. Lubricating or machinery oil.

Natural springs of rock oil have long been known in several localities of Western Canada. Two of these are in the township of Enniskillen, in the southern part of which are two patches of an acre or more, covered with a layer of several inches of viscid mineral tar or asphaltum, which has resulted from the drying up of the petroleum of these springs. Wells sunk in their vicinity, to a depth of from forty to sixty feet, through the superficial clays, encounter a stratum of gravel, resting on the surface of the rock beneath, and often filled with oil, giving origin to what are called surface wells. On boring into the underlying soft fossiliferous shales and limestone, fissures are met with at various depths, from which rise abundant supplies of oil, often accompanied with inflammable gas, and with water, which is sometimes saline. These fissures, which also supply the surface wells, are apparently connected with the oil-bearing strata of the corniferous limestone, which is from 200 to 300 feet below the surface, in Enniskillen. Within an area of about four square miles in the first three ranges of this township, there were supposed to be, in August, 1861, about seventy wells, yielding more or less oil. Of these, forty were surface wells, that is, wells sunk from 40 to 60 feet, through the drift clay and gravel, to the rock beneath. Some of these latter, which had yielded but little oil, gave abundant supplies by boring into the rock. The oil-bearing fissures or veins, in adjacent wells were met with at depths varying from 36 to 100 and even 150 feet from the surface of the rock. One of the most abundant occurred at 60 feet. In some few cases the oil from the borings rises above the surface of the ground, constituting what are called flowing wells.

It is not easy to know the amount of oil which these wells are capable of supplying; since from the great difficulty in getting it to market, arising from the want of good roads, few of the wells are regularly and continuously pumped. Some of those which were bored in July and in August last, are said upon good authority, to have yielded from 400 to 500 barrels of oil in a week or two after having been opened; but the reservoirs provided, being filled with oil, the pumping of the wells was suspended. Two bored wells, belonging to Mr. Williams, which were the only ones continuously wrought in August last, are said to have yielded together, during some months, from 20 to 25 barrels (of 40 gallons each) daily. About 6 miles to the northward, at Petrolia, on lots 13 and 14 of ranges 10 and 11 of the same township, 16 wells had been sunk last August; of which 12 were surface wells, and had yielded large quantities of oil. Several of these had been wrought for nearly twelve months, and were sup-

posed in that time to have yielded 1,000 barrels. Other wells had recently been bored to a depth of nearly 200 feet, but yielded less oil than the surface wells. The wells of this region seem, thus far, to be less important than those in the southern part of the township. The oil from the deep or rock is somewhat lighter and more fluid than that from the superficial wells, which is very dark coloured and somewhat viscid.

Great expectations have recently been excited by a flowing well, known as Shaw's, which was sunk to a depth of about 200 feet, and when first opened, a few weeks since, was supposed to yield, for a short time, 2,000 barrels of oil in 24 hours, which flowed into a stream close by and was lost. This well is, however, said to have been since closed, so that the discharge is under control. Another recent well, near by, known as Bradley's, is nearly as abundant. The experience in Pennsylvania has, however, shown that the supply from these flowing wells soon diminishes, and eventually fails. Adjacent borings sometimes appear to be connected with the same oil-yielding fissure, and to affect each other's supply; in some cases air passes down one shaft when the other is pumped.—*Corniferous formation, Devonian.*

2. Tilsonburgh, Watkins and Inglis, Hamilton.

a. Crude oil from the well.

Near the village of Tilsonburgh, in the township of Dereham, natural oil springs occur, and two wells have been bored in the Devonian limestone, which is here covered by about 40 feet of clay and sand. One of these had been sunk 36 feet in the limestone, and had furnished when seen, in August, a few barrels of oil.

In the townships of Zone, Mosa, and Orford, on the banks of the Thames, oil springs abound for a distance of about 4 miles. These, like the other natural springs mentioned above, furnish but small quantities of oil; several wells have, however, been sunk in the clay, and the rock beneath has been drilled. One of these, at a depth of 70 feet in the clay, had yielded about 40 barrels of oil.—*Corniferous formation, Devonian.*

3. Bertie, lot 13, range 1, geological survey.

a. Specimen of the limestone yielding the oil.

In a quarry on the lot indicated, 2 oil-bearing beds, one of 2 and another of 6 inches, are seen; they are made up in great part of corals of the genera *Heliophyllum* and *Favosites*, in the pores of which the oil is lodged like honey in a comb. Other coral beds in the same series, however, are quite free from oil. The limestone beds above and below these are compact, and not at all impregnated with oil, which, even in the coral beds, is seen, when these are freshly broken, to be confined to the fossils, and not to be uniformly disseminated in the layer. When the rock is quarried, the oil flows out, and may be collected on the water in the bottom of the quarry. The facts observed with regard to the petroleum springs in Canada and the United States, would seem to show that they are always on the lines of anticlinals, along which the oil from its superior levity accumulates, and afterwards, by the pressure of water, is raised to the surface through the natural fissures, which generally occur upon anticlinals. The oil-bearing limestone underlies an area of 7,000 square miles in Western Canada. This limestone is of marine origin, and contains no organic remains but those of marine animals; so that we are led to conclude that these hydrocarbons have been derived from a peculiar decomposition of their tissues. These tissues, as is well known, differ but little from those of the plant, which in many more recent formations have given rise to bitumens. We may suppose that many soft gelatinous animals, and perhaps plants, whose traces have disappeared, may have contributed to form the petroleum of these coral beds.—*Corniferous formation, Devonian.*

BITUMINOUS SHALE.

1. Collingwood, lot 23, range 3, geological survey.

a. Shale from the bed.

b. Burning oil.

c. Lubricating oil.

The shale of Collingwood, on lot 23, range 3, yields, when distilled, from 3 to 4 per cent. of tarry oil, which, by the usual process of rectification, affords oil fit for illumination and lubrication. Works were erected by Messrs. Pollard and Macdonell in October, 1859, consisting of 24 retorts, and capable of yielding about 250 gallons of oil daily, by the distillation of from 20 to 30 tons of shale. The available bed of shale is 7 feet in thickness, and the material was delivered broken for the retorts, at 20 cents the ton. The cost of the crude oil was said to be 14 cents the gallon, and for a while the works were carried on successfully, a ready market being found for the oils; but the works were repeatedly destroyed by fire, and the oils from this source coming into competition with petroleum from the oil wells at Enniskillen, the enterprise for the present was abandoned.—*Utica formation, Lower Silurian.*

ARE GAS HOLDERS LIABLE TO EXPLOSION FROM THE EFFECTS OF EXTERNAL FIRE?

By THOMAS W. KEATES, F.C.S.*

During the progress of a recent conflagration which happened in the immediate neighbourhood of one of the largest of the metropolitan gas works, considerable excitement and alarm were experienced by many of those living in the adjoining streets or present in the crowd, from the idea that if the fire extended to the gas holders, which at the time were filled with gas required for the supply of the public and private light, an explosion of unexampled force would be the result. It was stated that many persons hastened away from the locality when they heard that there was a probability of the flames reaching the gas works; some thinking that if an explosion occurred, even the dome of St. Paul's might be endangered; others, that at least Blackfriars-bridge would be destroyed; and, indeed, the public mind was filled at the moment with that vague and unreasonable sense of danger, which, operating upon great masses of people, effectually prepares the way for the most dangerous panic.

It is very desirable, both in the interests of the gas companies and of the public, that the erroneous ideas which gave rise to these really absurd, although in some respects natural, fears, should be corrected. There is but one way in which this can be done, that is, by affording information concerning the agents and forces involved in the question, so that a clearer conception of their nature may be acquired, and the undefined terrors, which in this, as in other similar cases, are engendered and fostered by ignorance, may be removed by a rational consideration of the physical and chemical laws to which such agents are subject.

In accordance with this view, there are, then, to be considered—first, the character of coal gas with reference to the question of explosion; secondly, whether explosive mixtures of coal gas can be produced by circumstances attendant upon a fire extending itself to the gas holders.

With regard to the first part of the inquiry, it must be remembered that the gaseous mixture which we know as coal gas, is not, *per se*, an explosive, although it is an eminently combustible, material. When ignited, it burns with the greatest rapidity, evolving an immense flame, and producing a very great amount of heat; but there is no more tendency to explosion than when coals, or any other combustible substances, are burning in a furnace. Certain constituents of coal gas require a very high temperature to inflame them, others are readily inflamed at a red heat; but the lowest point at which any one of its constituents may be inflamed must be taken as the index of the point of inflammation of the mixture,

* Reprinted from Newton's London Journal.

and this may be, perhaps, set at a red heat. When coal gas burns in the air, it is, of course, at the expense of the atmospheric oxygen, the process simply consisting in the oxidation of the carbon and hydrogen of the gas; and this action is necessarily confined to the exposed surface. Under such circumstances, the oxidation goes on gradually, and a certain time is required to bring in contact the combustible atoms and the oxygen; we have then burning, but no explosion. To effect complete oxidation, coal gas consumes, or rather combines with, about two and a half times its bulk of oxygen, which are equal to more than twelve times its bulk of atmospheric air. If, however, the required quantity of oxygen, or of air containing the oxygen, be mixed with coal gas before the latter is inflamed, and means of inflaming the gas be then applied, combustion will not progress gradually, as it does when the gas alone is inflamed, but will occur atomically as it were—that is, each atom of gas finding in its immediate proximity an atom of oxygen, the union between the two will take place throughout the whole volume of the gaseous mixture instantaneously, and a violent explosion will be the result. To produce this explosion, oxygen, in certain proportion, must be mixed with the gas before ignition. In the absence of oxygen, previously so mixed, there can be no explosion.

Sir H. Davy, in his important and interesting experiments upon this subject, found that light carburetted hydrogen, the most powerfully explosive of the gases, required about seven times its bulk of atmospheric air to be mixed with it to produce the greatest explosive effect; practically, it may be calculated that from eight to nine times its bulk of air will produce the most explosive mixture with coal gas; but, as was remarked before, the air and gas must be mixed before inflammation. No matter how rapidly the air may be supplied when the gas is burning, that will merely increase the fierceness of the combustion; but there will be no explosion. To form an explosive mixture, the gas must be present in quantity varying from 7 to 25 per cent. of volume; if it fall short of, or exceed, that proportion, it will burn away quietly, and not explode. So it will be perceived that, in the contents of the gas holders, we have to deal with a material which is combustible in the highest degree, but which in itself, even when burning, has no tendency to explode, and which cannot be made to explode excepting by changing its normal state by previous admixture with a foreign gas, viz., oxygen.

There is another property of coal gas which relates to this inquiry, and which it possesses in common with all matter—that is, expansibility under increased temperature. When a gas is heated, its volume is augmented. For every degree of Fahrenheit's thermometer this augmentation equals $\frac{1}{480}$ th part of the bulk of the gas at 32°. so that the volume of gas being 480 cubic inches at 32°, it would be 481 at 33°, 482 at 34°, and so on. The qualities of coal gas, then, which relate to the question of explosion of gas holders are—combustibility, capability of forming explosive mixtures with oxygen gas or air, and susceptibility of having its bulk or volume increased by rise of temperature.

In relation to the second part of the subject, it remains to see how far circumstances arising from the application of heat or flame to the exterior of a gas holder could so effect or modify its contents as to produce explosion, as many persons have seen cause to dread. In the gas holder itself we have an apparatus very well calculated to preserve the gas which it contains from any admixture with the external atmosphere; and, indeed, under all ordinary circumstances, such admixture is impossible. It must be remembered that the gas holder, formed of strong plate iron, is so arranged that it is only capable of moving vertically, under the guidance of firmly constructed iron rods and pillars, and that, during all its movements, its lower edge remains immersed in a tank of water; were it not so, its contents could not be preserved at all, as it must be remembered that gas holders

rise, in consequence of the elastic raising power of the gas which is forced into them, and are not *suspended*. The moment the gas is removed by any means from the holder, the latter sinks by virtue of its weight, which operates as a powerful expulsive force, and is, in fact, the only force which sends the gas through the almost endless ramifications of pipes by which it is distributed for public consumption. Are there, then, any conditions in which the gas in the holder could become mixed with a sufficient quantity of air to be rendered explosive; those conditions, of course, being produced by the action of heat applied externally to the holder?

Some years since it happened, at one of the London gas works, that a portion of the upper part of the heavy iron framework which guides the holder became detached, and, falling upon the top or crown of one holder, crushed through, making a large hole in the iron plate. The weight of the holder caused the gas to rush through this opening with great velocity; reaching a light which was burning near, it became ignited, and, as may be supposed, a flame of immense size and force—a sort of gigantic blow-pipe flame—was produced: as the aperture was of considerable size, the whole of the gas was, however, expelled from the holder in a very short time, and no damage was done—nothing in the remotest degree resembling explosion having occurred. Suppose, during a great fire at a gas works, that by any means the gas holder became perforated, the only result would be that just described; and even if the perforation were made in a part of the holder from which the flame might prove a means of extending the conflagration, there would be no danger of explosion, unless, as we have seen before, the gas holder contained a mixture of gas and atmospheric air or oxygen. Is there, then, any probability of such an explosive mixture being produced in a gas holder through the effect of an external fire?

If a gas holder, filled with gas, were exposed to the action of violent flame, it is evident that, in accordance with the law of expansion, already explained, the volume of the gas would be rapidly increased. It is scarcely in the nature of things that a large gas holder should be uniformly heated on every side; but, for the sake of illustration, let it be supposed that the whole mass of the gas is raised to 1,000°, a very high temperature, about equal to bright red heat;* under these circumstances the volume of the gas would be nearly tripled, so that from a gas holder capable of containing 3,000 cubic feet, nearly two-thirds of the contents would be expelled by mere expansion—that is, if the holder were at first filled to its full capacity. As the holder cannot rise out of the water of the tank, owing to the iron framework by which it is held, the excess of gas (that is, 2,000 cubic feet) would be forced under the edge of the holder, and would bubble up through the water, a thing which not uncommonly happens on a limited scale in gas works when the holders are over-filled; as the gas thus escaped, it would, of course, inflame, and a succession of irregular fierce combustions, so to speak, would be the consequence; but as the gas could not previously have been mixed with air, there would be no explosion. Now, let us suppose the source of heat to be removed, the fire about the gas

* I am here intentionally ignoring the circumstance that no such temperature as this could ever exist in a gas holder and its contents in the presence of the water in the tank; so soon as the bulk of the gas became heated much above 212 deg. Fahr. the water would give off steam from its surface, and this steam would mix with the gas, and, by increasing the volume of aeriform matter in the holder, expel the gas, the place of which would soon be occupied by steam alone. This is obvious when we consider that one cubic foot of water would produce more than 1,700 cubic feet of steam, and that it would, consequently, require less than two cubic feet or about twelve gallons of water to generate steam enough to entirely fill such a holder as that spoken of. For the sake of the argument, however, I am supposing that the water of the tank remains unaffected by the temperature of 1,000 deg. Fahr.

holder to be subdued, for example, the contained gas would cool, and, in cooling, would contract to its normal density; this being so, it would only be capable of occupying one-third of the capacity of the holder, which would, of course, descend as the contraction progressed, and the result would be, not that of any mixture of air and gas had been produced in it, but that the gas holder would be found less elevated from the tank by two-thirds of the height which it reached when first subjected to the action of the heat.

Let us, however, take an extreme case, in which the holder, filled with gas, expanded to three times its normal volume, is suddenly cooled, and in which, from the action of the fire, the guides or pulleys of the holder itself have been so deranged that the holder cannot descend upon the contracted gas—it is obvious that the gas, in cooling, will, as in the former case, be only capable of filling one-third of the holder; the water of the tank cannot rise to fill the vacant space; atmospheric air would therefore pass under the edge of the holder, or blow through the water seal; and very shortly the contents of the holder would consist of about one-third of gas and two-thirds atmospheric air; even then the mixture would not be explosive. Davy's experiments show that, when the gas present in the mixture exceeds from 20 to 25 per cent., it burns quietly, and does not explode; and in the above case—a most unlikely one to occur—the gas is present in the proportion of 33 per cent. If a gas holder became fixed by any means, in the manner spoken of, and by accident the side of the tank were broken down, so that the water flowed away from the holder, the contained gas would be in communication with the atmospheric air; in that case, however, the mixture of the two would be but a slow operation, as by its superior levity, the gas would continue to occupy the suspended holder until sufficient time had elapsed for diffusion of gas and air to take place. If flame were to be brought in contact with the contents of the gas and holder shortly after the occurrence of such an accident, which would, of course, happen if the injury to the tank were caused by fire, there would be still no explosion, but burning of the gas from the surface upwards, as in a common lecture-table experiment, where combustible gas, contained in an inverted jar, is ignited at its inferior surface, and extinguishes a lighted taper plunged into its mass. As to the gas holder itself being so much damaged by the action of the heat or flame as to be rendered incapable of containing the gas, such a thing is scarcely possible. It is well-known that rivetted sheet-iron vessels will bear a lengthened exposure to a red heat before they are so much injured as to become leaky; and if, in the case of the gas holder, the sudden action of powerful flame, striking on its exterior, were so to twist and warp the plates, that the gas could escape, there would simply be combustion of the gas as it issued from the openings, as in the case of the perforated gas holder first discussed.

A little consideration of this subject seems to show, then, that the explosion of a gas holder, from circumstances created by the influence of a conflagration in a gas works, is an event, not perhaps beyond the bounds of possibility, but so far removed from anything like probability, that any serious fears in connection with it must be looked upon as entirely groundless. Such an occurrence seems never to have taken place in the whole course of gas-making practice; and if we reflect upon the natural laws which operate in the matter, it is to be presumed that it could scarcely be made to happen under the influence of any external circumstances. It cannot be denied that a conflagration may be increased to a fearful extent by the contents of a gas holder becoming ignited, but it may be safely questioned if, in any case, there is the slightest danger to be apprehended from explosion.

NEW BAROMETER.

The New Standard Barometer, invented by Mr. Symons, is described by him as designed to overcome the practical objections to Gay Lussac's syphon-barometer, which would probably be much more used but for two reasons—the absence of any arrangement for making it effectually portable, and the use of a vernier and scales to both limbs of the syphon, necessitating two observations, which must be added together to obtain a correct reading. The instrument exhibited by Mr. Symons has a simple arrangement for making it portable, and, instead of two verniers, there is a continuous inside brass tube, to be adjusted by a rack to the level of the mercury in the lower limb of the syphon-tube. The barometer is read off by the vernier attached to the top of this internal and moveable tube in the same way as in Fortin's or other standard barometers. No cistern is required, and therefore the instrument is much lighter, simpler, and of course of cheaper construction than Fortin's or other similar barometers, while it appears to possess all the desiderata of a standard barometer, and can be accurately adjusted more quickly than an instrument with an ivory point dipping in the mercurial cistern.

MEETINGS FOR THE ENSUING WEEK.

- MON. ...Entomological, 7.
British Architects, 8. Annual Meeting.
Asiatic, 3.
Royal Inst., 2. General Monthly Meeting.
Geologists Association, 7. 1. Mr. J. Roze, F.G.S., "On some Recent Shells found in Lancashire." 2. Professor Tennant, "Geological Ramble on the Banks of the Medway."
- TUES. ...Civil Engineers, 8. Mr. Zerah Colburn, "American Iron Bridges."
Pathological, 8.
Photographic, 8.
Ethnological, 8.
Architectural Museum, South Kensington, 7½. Sir Henry Dryden, Bart., "On Construction and Ornament, Old and New."
Royal Inst., 3. Prof. Tyndall, "On Sound."
Royal Horticultural. Floral Committee, Fruit Committee, 12. Opening of Exhibition of Sculpture, 1.
- WED. ...Society of Arts, 8. Dr. Andrew Wynter, "On Bread Making, particularly with Reference to the Condition of those Employed in its Manufacture."
Geological, 8.
R. Soc. Literature, 8½.
- THURS. ...Royal, 8½.
Antiquaries, 8½.
Linnean, 8. Mr. John Lubbock, F.R.S., "On two Aquatic Species of *Hymenoptera*."
Chemical, 8. Dr. Lyon Playfair, "On the Constitution of Salts."
Royal Soc. Club, 6.
Artists and Amateurs, 8.
Royal Inst., 3. Prof. Ansted, "On Geology."
- FRI. ...Astronomical, 8.
Royal Inst., 8. Prof. Voelcker, "Soils of England."
R. United Service Inst., 3. Capt. C. C. Chesney, R.E., "The Recent Campaigns in Virginia and Maryland."
Royal Botanic, 3½.
- SAT. ...Royal Inst., 3. Professor Max Muller, "On Language."

PATENT LAW AMENDMENT ACT.

APPLICATIONS FOR PATENTS AND PROTECTION ALLOWED.

866. T. Burrow, Albert-place, Brighouse, near Normanton—Imp. in, and machinery for, combing and dressing silk, flax, wool, hemp, China grass, and other fibrous materials.
868. M. Henry, 84, Fleet-street—Imp. in probes, catheters, and similar surgical instruments. (A com.)
870. J. Burwin, Keighley, Yorkshire—Imp. in pickers, and in the means or apparatus employed in the manufacture thereof.
- Dated 7th April, 1863.*
874. A. C. Bamlett, Ripon, Yorkshire—Imp. in reaping and mowing machines.
878. R. A. Brooman, 166, Fleet-street—Imp. in the manufacture of baryta and its derivatives, in obtaining by-products, and in revivifying or recovering certain agents employed in such manufacture. (A com.)
- Dated 8th April, 1863.*
882. G. Hill and W. R. Hill, Bolton—Imp. in steam boilers.

884. J. Mosheimer, Dolgelly, Merionethshire—Certain imp. in machinery or apparatus for crushing, grinding, and dressing metallic, ores, quartz, and other similar substances.
 888. W. E. Gedge, 11, Wellington-street, Strand—Imp. in apparatus for propelling and navigating small craft. (A com.)
 890. J. L. Norton, Belle Sauvage-y rd, Ludgate hill—Imp. in machinery for washing and drying wool and other fibres and rags, also in tendering, stretching, and drying fabrics.

Dated 8th April, 1863.

892. H. B. Fox, Liverpool—Imp. in dish covers.
 902. A. V. Newton, 66, Chancery-lane—An improved construction of offensive weapon. (A com.)
 904. A. V. Newton, 66, Chancery-lane—An imp. in stirrups, and in the mode of attaching the same to saddles. (A com.)

INVENTION WITH COMPLETE SPECIFICATION FILED.

906. S. A. Couperie, Bordeaux—A semi-circular metallic slide, whereby the pole bolt is effectually suppressed, and which can be adapted to every four-wheeled vehicle.—10th April, 1863.

[From Gazette, April 24th, 1863.]

Dated 22nd December, 1862.

3414. A. S. Stocker, Wolverhampton—Imp. in rolling iron for the manufacture of tips and other articles.

Dated 15th January, 1863.

127. H. Turner, Leeds—Imp. in apparatus for preventing and curing blight, decay, disease, and rot in potatoes.

Dated 18th February, 1863.

450. J. Gray and J. Hudson, Botolph-lane—Imp. in the treatment of steatite, and in its application to certain purposes.

Dated 24th February, 1863.

496. H. Masters, Bristol—Imp. in spools, bobbins, rollers, and similar articles.

Dated 3rd March, 1863.

601. J. Pollard, Leeds—Imp. in warp dressing, and in apparatus connected therewith. (A com.)

Dated 5th March, 1863.

622. W. Jackson and R. Watkins, Millwall, Poplar—Imp. in steam engines.

Dated 6th March, 1863.

637. W. E. Gedge, 11, Wellington-street, Strand—Imp. in steam engines. (A com.)

Dated 11th March, 1863.

667. W. Wood, Monkhill, near Pontefract—Imp. in the manufacture and ornamentation of pomfret or liquorice cakes, rolls, sticks, and pipes, and other similar articles of confectionery.

Dated 21st March, 1863.

753. I. M. Evans, Cefn Mawr, Denbigh, and W. T. Griffiths, Merthyr Tydvil—Improved means for ventilating mines.

Dated 1th April, 1863.

872. J. Swinburne, Alfred Town, Ashford, Kent, and J. Stanley, Whitechapel road—Imp. in steamengines and generators.
 876. J. H. Johnson, 47, Lincoln's inn-fields—Imp. in machinery or apparatus for drying grain, applicable also to the manufacture of malt. (A com.)
 880. J. Howard, E. T. Bousfield, and J. Pinney, Bedford—Imp. in steam engines, and in the means of applying the same to the tilling of land, also in apparatus to be used with such engines in the tilling of land.

Dated 9th April, 1863.

896. G. Spencer, 2, Lousanne-villas, Queen's road, Peckham, Surrey—Imp. in preventing incrustation in steam engine boilers.
 900. Vice-Admiral J. R. Burton, K.H.A., 15, Park-square, Regent's-park—A new method of and apparatus for cleansing ships' bottoms.

Dated 10th April, 1863.

908. S. Shelmerdine, Stockport, and J. Dransfield, Oldham—Imp. in the ornamentation by printing of felt hats.
 912. J. Gimson, Leicester—Imp. in screw cutting lathes.
 914. H. Caudwell, Oatlands-house, Shillingford, Oxfordshire—Imp. in the construction of vessels of war, part of which imp. is applicable to fortifications.

Dated 11th April, 1863.

916. J. Lockwood, Batley, Yorkshire—Imp. in steam boiler and other furnaces.
 918. W. Samuel, Liverpool—Imp. in or applicable to railway carriages to mitigate or lessen the effects of collision to passengers.

920. W. Clark, 53, Chancery-lane—Imp. in separating ores from their gangues, and in apparatus for the same. (A com.)
 922. A. F. Maclure, Glasgow—Imp. in looms for weaving figured fabrics.

Dated 13th April, 1863.

924. J. Ramsbottom, Crewe, Cheshire—Imp. in machinery for hammering, rolling, and shaping metals.
 926. A. Rolfe, Amwell-street, Pentonville—Imp. in means or apparatus for propelling carriages on railways, tramways, or on common roads.
 932. T. Mallinson and P. Williams, Manchester—Imp. in machinery for opening, cleaning, carding, and grinding or sharpening cards used in preparing cotton and other fibrous materials.

Dated 14th April, 1863.

934. G. Berry, 19, Bultesland-street, Hoxton—Imp. in locks.
 936. W. Keats and J. Keats, Street, Somerset—Imp. in the manufacture of boots, shoes, or other coverings for the feet.
 938. J. Keats and W. S. Clark, Street, Somerset—Imp. in sewing machines.
 942. J. Smith, Edward street, Wentworth-road, Bow-road-east—Imp. in furnaces and boilers for the generation of steam, partly applicable also for other purposes.

PATENTS SEALED.

[From Gazette, April 24th, 1863.]

April 24th.

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| 2865. L. Groux. | 2940. D. Spink. |
| 2889. T. Pilgrim. | 2955. J. W. Taylor. |
| 2891. J. J. Ridge. | 2962. F. Tussaud. |
| 2892. P. E. Placet. | 2966. F. Trachel and T. Clayton. |
| 2893. G. Lindemann. | 2970. T. O. Clark. |
| 2898. E. Hooper. | 2986. J. Shirt. |
| 2900. E. Tatham & A. Tatham. | 3001. J. J. Laveissiere. |
| 2903. E. S. Tudor. | 3010. C. O. Heyl. |
| 2906. T. Sutton. | 3021. E. Sonstadt. |
| 2907. A. Viple. | 3029. R. R. Holmes. |
| 2908. A. Shanks and F. Kohn. | 3049. J. Faulding. |
| 2918. W. E. Gedge. | 3055. G. W. Rendel. |
| 2922. F. L. Stott. | 2065. C. G. Kopisch. |
| 2926. H. Eastwood. | 3075. E. Kirby. |
| 2927. F. Gregory. | 267. J. Pouncy. |
| 2931. P. Giffard. | 395. J. A. Schlumberger. |
| | 516. H. Wilde. |

[From Gazette, April 28th, 1863.]

April 28th.

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| 2942. C. Gubbins. | 3028. S. Berrisford and W. Ainsworth. |
| 2969. W. Clark. | 3047. T. Bradford. |
| 2971. D. Scattergood. | 3051. J. A. Duntze. |
| 2973. R. A. Brooman. | 3074. L. Croc. |
| 2974. W. H. Stallard. | 3102. J. Oxley. |
| 2976. J. Lefebvre. | 3104. H. J. F. Marmet. |
| 2977. F. Durand. | 3113. G. A. Buchholz. |
| 2982. P. W. Reuter. | 3143. C. De Bergue. |
| 2983. T. Huntley. | 3165. A. V. Newton. |
| 2984. R. A. Brooman. | 3241. A. T. Becks. |
| 2988. A. Wall. | 3314. W. A. Turner. |
| 2998. J. Petrie, jun., and J. Teal. | 92. D. Dawson. |
| 3008. J. A. Fullarton. | 162. R. A. Brooman. |
| 3013. T. Greenwood and J. Schofield. | 184. A. Boubee. |
| 3016. H. Kilshaw and E. Lord. | 263. T. A. Weston. |
| 3023. J. Mellodew, T. Mellodew, and C. W. Kesselmeier. | 411. F. E. Walker. |
| | 482. A. Dugdale. |
| | 579. J. W. Burton. |
| | 678. E. H. Lomas. |

PATENTS ON WHICH THE STAMP DUTY OF £50 HAS BEEN PAID.

[From Gazette, April 28th, 1863.]

April 21st.

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| 1008. J. Parkinson. | 1042. J. G. West. |
| <i>April 23rd.</i> | <i>April 24th.</i> |
| 1017. E. Hillam & R. R. Witton. | 1056. W. J. Harvey. |
| 1033. T. A. Claeys. | 1089. H. T. Green and S. B. Wright. |

PATENTS ON WHICH THE STAMP DUTY OF £100 HAS BEEN PAID.

[From Gazette, April 28th, 1863.]

April 22nd.

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| 1211. C. De Jongh. | 1003. C. A. Arnaud. |
| <i>April 24th.</i> | 1026. T. Heifor. |
| 997. R. Lakin, J. Thompson, E. G. Fitton, & F. A. Fitton. | |

LIST OF DESIGNS OF UTILITY REGISTERED.

No. in the Register.	Date of Registration.	Title.	Proprietor's Name.	Address.
4549	April 16.	Flexible Bottle	Alfred Warn Banks	67, Newgate-street, E.C.
4650	" "	The Albert Edward Scarf	W. Bacon and Thos. Hawley	7, King-street, Coventry.
4651	" 23.	{ Prince of Wales Waterproof Shooting } Boots	Samuel Baker	48, Lombard street, E.C.
4552	" 27.	Scarf Fastener	Ebenezer Banes	85, Newgate-street, E.C.
4553	" "	Boot or Shoe Warmer	Henry Doulton and Co.	63, High-street, Lambeth.
4554	" 29.	The Alexandra Jelly Mould	Benham and Froud	40, Chandos-street, W.C.